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A BALLISTICS RANGE STATION IDENTIFICATION SYSTEM TO BE USED IN CONJUNCTION WITH A DATA RECORDER-REPRODUCTION

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Ballistics Research Report 55

A BALLISTICS RANGE STATION IDENTIFICATION SYSTEM TO BE USED IN CONJUNCTION WITH A DATA RECORDER-REPRODUCER

Prepared by:

R. C. Folz

ABSTRACT: A ballistics range station identification system has been designed and constructed that provides a unique correlation of a series of elapsed time measurements as recorded by a data recorder-reproducer, with their respective sources. The final data readout is presented in a visual manner and is also automatically printed out by a Flexowriter. The identifying information is presented with the elapsed time data for each measurement that was recorded.

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The author wishes to acknowledge the assistance of Mr. J. W. Roberts for his aid in devising the technique used in coding the stations. The author also wishes to express his appreciation to Messrs. J. Barbera and L. Raborg for their assistance in the construction and installation of the many electronic circuits that constitute the system.

W. D. COLEMAN
Captain, USN
Commander

A. E. Seigel

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By direction

ILLUSTRATIONS

INTRODUCTION

The Data Recorder-Reproducer (DRR), see reference (a), is an elapsed time measuring system. This system accepts a series of voltage pulses and records, on a magnetic drum, the time of occurence of each of these data pulses relative to an initial pulse which is used as a fiducial timing pulse. A series of time measurements is obtained from which the precise elapsed time between the occurence of the data pulses and the fiducial pulse can be determined. In the ballistics range operations at the Naval Ordnance Laboratory, this series of voltages is derived from the triggering of instrumented photographic stations as a projectile progresses down the range (see ref. (b)).

The means of distinguishing between the individual photographic stations is by assigning a decimal number to each station. This assignment is completely arbitrary and serves only to correlate the several types of data obtained at each station with their source. The range station identification system provides the means of correlating the time data as recorded by the DRR with the particular station from which it originated.

The station identification system is an auxiliary system to the DRR and it makes use of six available channels on the magnetic drum in the DRR. The auxiliary system uses a binary coded decimal (BCD) number system and with six recording channels available, 39 individual range stations can be identified. If a greater capacity is desired, additional channels can be incorporated or a different coding technique can be used. The system operates in conjunction with the DRR as shown in figures 1 and 6 and as described below.

DESCRIPTION OF THE SYSTEM

The ballistics range station identification system operates on the principle of converting the assigned decimal number of the individual range stations into a binary coded form which can then be handled by normal digital techniques. The digitized information is amplified and recorded on a magnetic drum in the DRR along with the appropriate time interval data. When information readout is desired the recorded data are played back through individual amplifier channels, converted back to decimal form, displayed visually on indicator tubes, and printed out by the Flexowriter along with the elapsed time data as recorded by the DRR. The

operation of the system can best be described by breaking it down into two modes of operation, the record mode and the playback mode. Each mode will be discussed below.

RECORD MODE OPERATION

When a photographic station is triggered, a voltage pulse is generated which performs two functions. First, it is fed through a mixer circuit and is used as the data pulse which "reads" the counters in the DRR. Secondly, it triggers a thyratron in the station fired indicator circuits (see fig. 1). The pulse derived from the thyratron is fed to a "binary coded decimal" (BCD) code converter which converts the assigned station number into a binary form which then can be handled by the system. The information in binary form is fed to the six record amplifier channels and is stored until an interrogation pulse is generated in the DRR. The generated interrogation pulse is used to read the information that is stored in the station coding record channels. The resulting information is then fed to the record heads and recorded on the magnetic drum along with the counter readings and the appropriate control signals.

Figure 2 shows the circuit diagram of the BCD code converter using a standard diode matrix converter system (see ref. (c)). Pulses will appear on certain output lines or lines depending upon which input is energized. The first four output lines comprise the digit in the "units" position of the two digit decimal number. The remaining two output lines comprise the digit in the "tens" position of the two digit decimal number. With the six channels available, 39 decimal numbers can be coded in the BCD system.

Figure 3 shows a block diagram of a typical station identification system with representative waveforms showing the time relationship of the pulses in the channel. The waveform represented at B of figure 3 is the amplified and shaped input pulse that drives unit 4 which is a 20-microsecond one-shot multivibrator. As a result of the one-shot action, a pulse is effectively stored in the channel for a period of 20 microseconds. This stored information is applied to the "And" gate, unit 5, as one of two inputs. The second input to the "And" gate is the interrogation pulse generated by the DRR and is represented at D. This pulse is delayed approximately 7 microseconds after the station fires, which is the reason for the need of the temporary storage. This delay is necessary because of the method of sampling the counters in the DRR. Thus, if there is a pulse at C at

the time an interrogation pulse arrives at D, the "And" gate will produce an output at E and a pulse is recorded on the magnetic drum which corresponds to a "1" recording. If there is no pulse at C, which corresponds to a "0" in the channel at the time an interrogation pulse arrives, there will be no pulse at E, and thus no pulse will be recorded which corresponds to a "0" recording.

Unit 1 is a transistorized amplifier and blocking oscillator circuit, see figure 4, that standardizes the input pulses for driving the pulse amplifier. The unit is built up into a single plug-in type module to facilitate the maintenance of the equipment. Units 2 through 7 are commercial type plug-in modules. Units 4 and 6 are basically one-megacycle flip-flops that have been modified as shown in figure 5 to operate as high-speed one-shot multivibrators. Unit 4 provides the temporary storage that is necessary and unit 6 provides the required pulse duration and amplitude for supplying the record head for recording on the magnetic drum.

PLAYBACK MODE OPERATION

In the playback mode of operation, the information that is recorded on the magnetic drum is amplified through the station coding playback amplifier channels at the same time as the data signals are played back through the data playback amplifier channels in the DRR (see fig. 6). When the desired reading number has been reached as dictated by the DRR, the resulting "read" pulse reads the data channels and also reads the station coding playback channels. The resulting read information is then stored into a thyratron-relay storage system until the Flexowriter completes the printout of the stored information. The relay contact arrangement converts the binary coded decimal number into a decimal number which is indicated on indicator tubes which provides the visual readout. The relay arrangement also converts the binary coded decimal number to the inverse BCD code required for Flexowriter operation. The Flexowriter then prints out the station number in decimal form along with the desired reading number of the elapsed time data that was obtained from that particular station. A typical shot data sheet is shown in figure 7.

Figure 8 shows a block diagram of a typical playback channel. All units are commercial plug-in type modules. Units 1 through 4 are amplifier units to produce as one of two inputs to unit 5 (an "And" gate), a positive pulse of 45 to 50 volts in amplitude, provided a "1" was recorded in that particular

channel. The second pulse applied to unit 5 is the "read" pulse from the DRR. Thus, for a particular "read" pulse, if a "1" was recorded in the channel an output would result. If a "0" (no pulse) was recorded in that particular channel no output would result. Unit 6 is an amplifier unit with external circuitry added to operate as a modified one-shot multivibrator. The output pulse is a positive pulse of approximately 2 milliseconds duration and is used to fire the thyratron in the thyratron-relay storage circuits shown in figure 9.

The thyratron-relay storage system uses standard thyratron circuitry with a plate circuit relay associated with each thyratron. The plate circuit relay contact arrangement is a basic two and a basic four transfer-tree arrangement with an additional set of contact for supplying Flexowriter information. The "A" levels of each relay provide the proper coding inputs to the Flexowriter for printed readout, and the remaining levels provide the proper routing of the ground connections to the indicator tubes for visual readout. Reset of the thyratrons, and thus the relays, is accomplished by disconnecting the plate voltage from the plate circuits of the thyratrons. The plate voltage is disconnected by an external relay contact opening when "end of reading" has been reached by the DRR. After sufficient time has allowed the Flexowriter carriage to return and all the circuitry to reset to the reset condition, then the equipment is ready to accept the next desired reading number that has been recorded by the DRR.

COMMENTS

The station identification system has been installed and checked out and is now in operation with the DRR. A few noise and pickup problems were encountered when first installed; however, these problems have been satisfactorily solved and at present the system is giving reliable operation.

Three facilities, the Aerodynamics Range No. 1, the Pressurized Ballistics Range No. 3, and the 1,000-ft. Hyperballistics Range No. 4 are presently incorporated with the station identification system. Other facilities contemplating the use of the DRR as the chronograph system and that require identification of the data pulses can also be incorporated with the system.

The completed system being integrated with the DRR will give much more data per shot than any previous system and will

also greatly reduce the amount of time previously required for the data reduction. The station identification system also lends itself to any automatic data reduction system that may be contemplated for use in the future.

References

(a) R. C. Folz and J. W. Roberts, "The Data Recorder-Reproducer - A Time Interval Measuring Instrument For Use In The Ballistics Facilities Of The Naval Ordnance Laboratory," NavWeps report 7307

(b) "Aeroballistics Research Facilities," NOLR 1233

(c) Caldwell, Samuel H., "Switching Circuits And Logical Design," John Wiley & Sons Inc. 1958

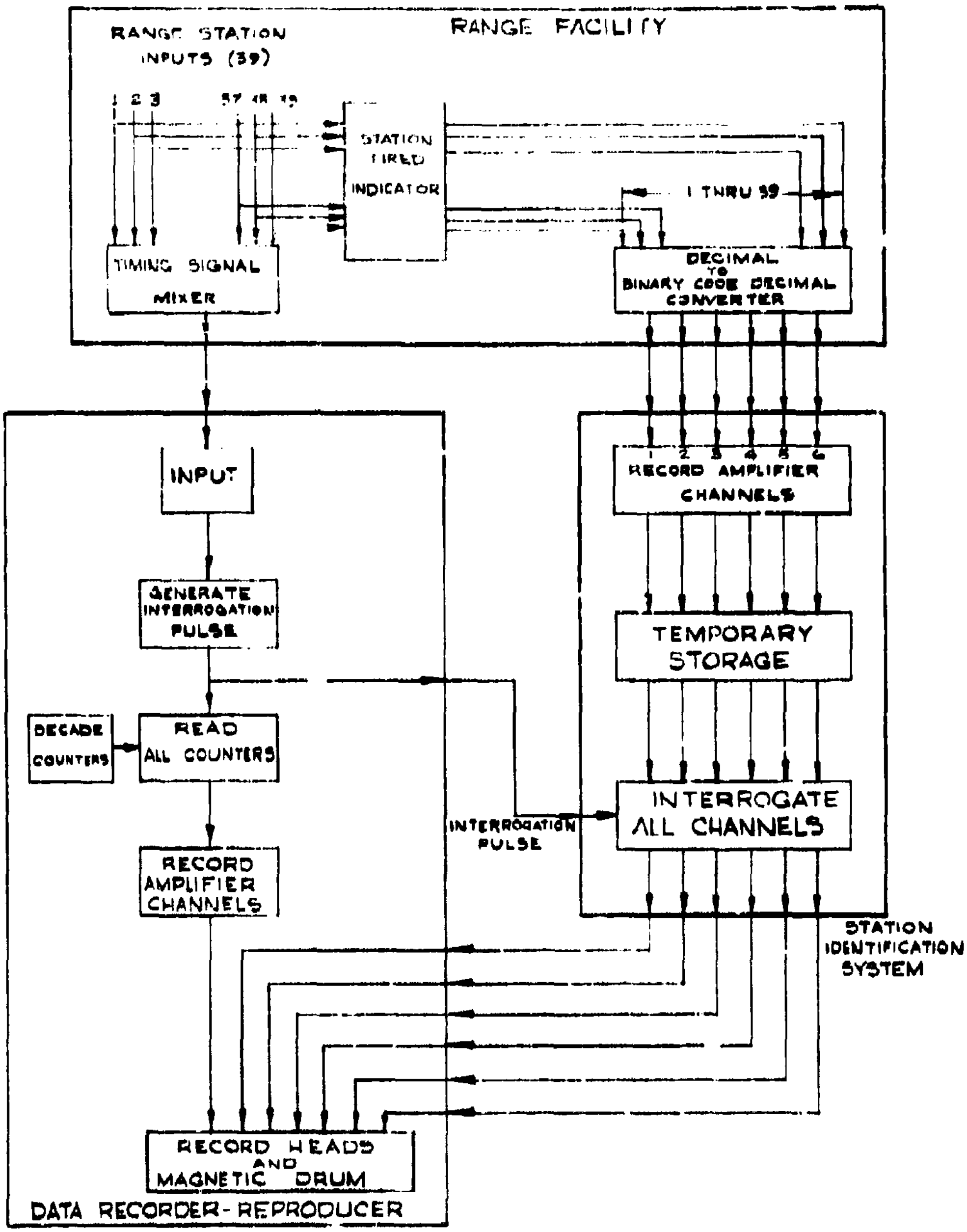


FIG. 1 SIMPLIFIED RECORD FLOW DIAGRAM

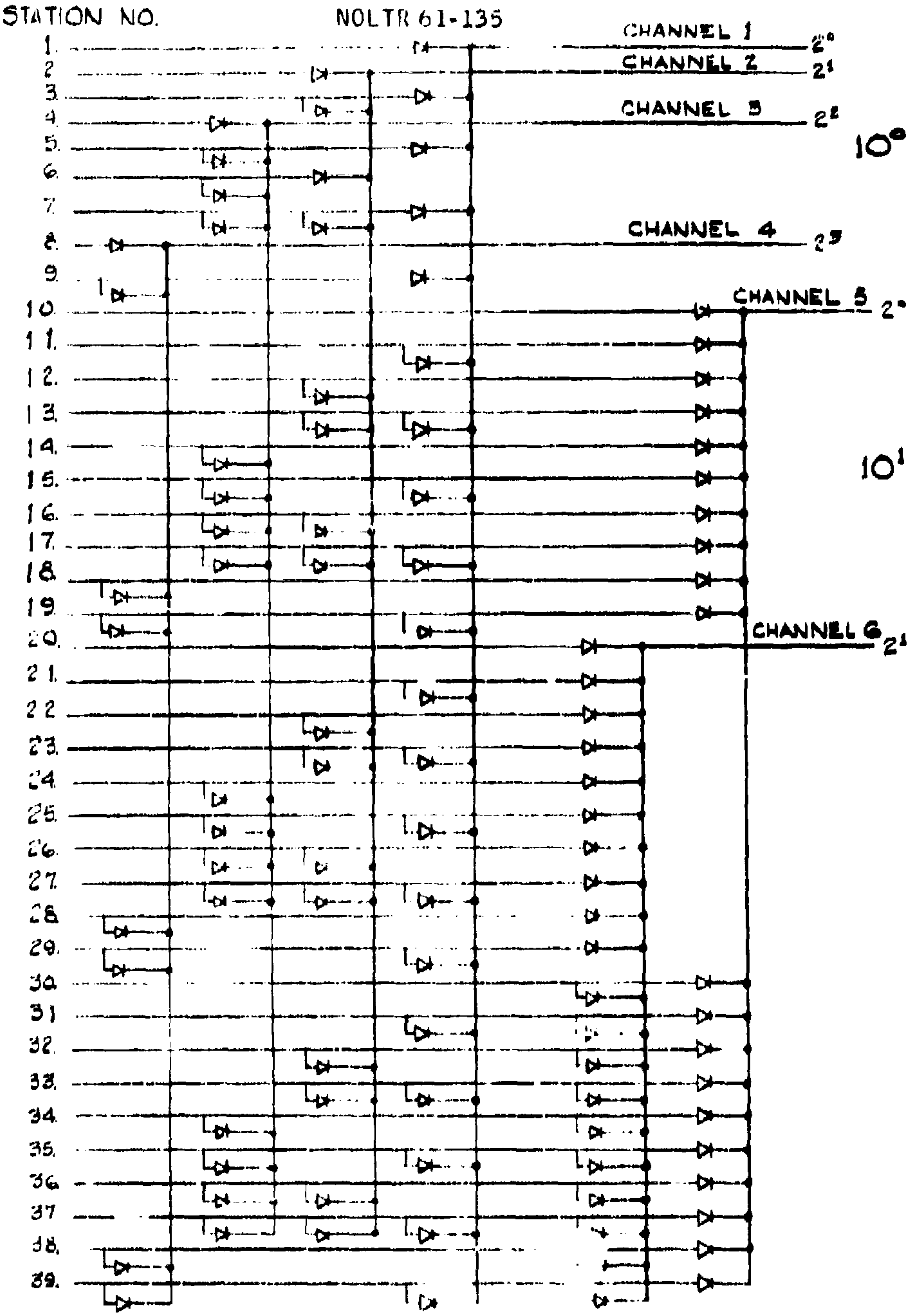


FIG.2 DIODE MATRIX FOR CONVERTING TO BCD FROM DECIMAL(1-39)

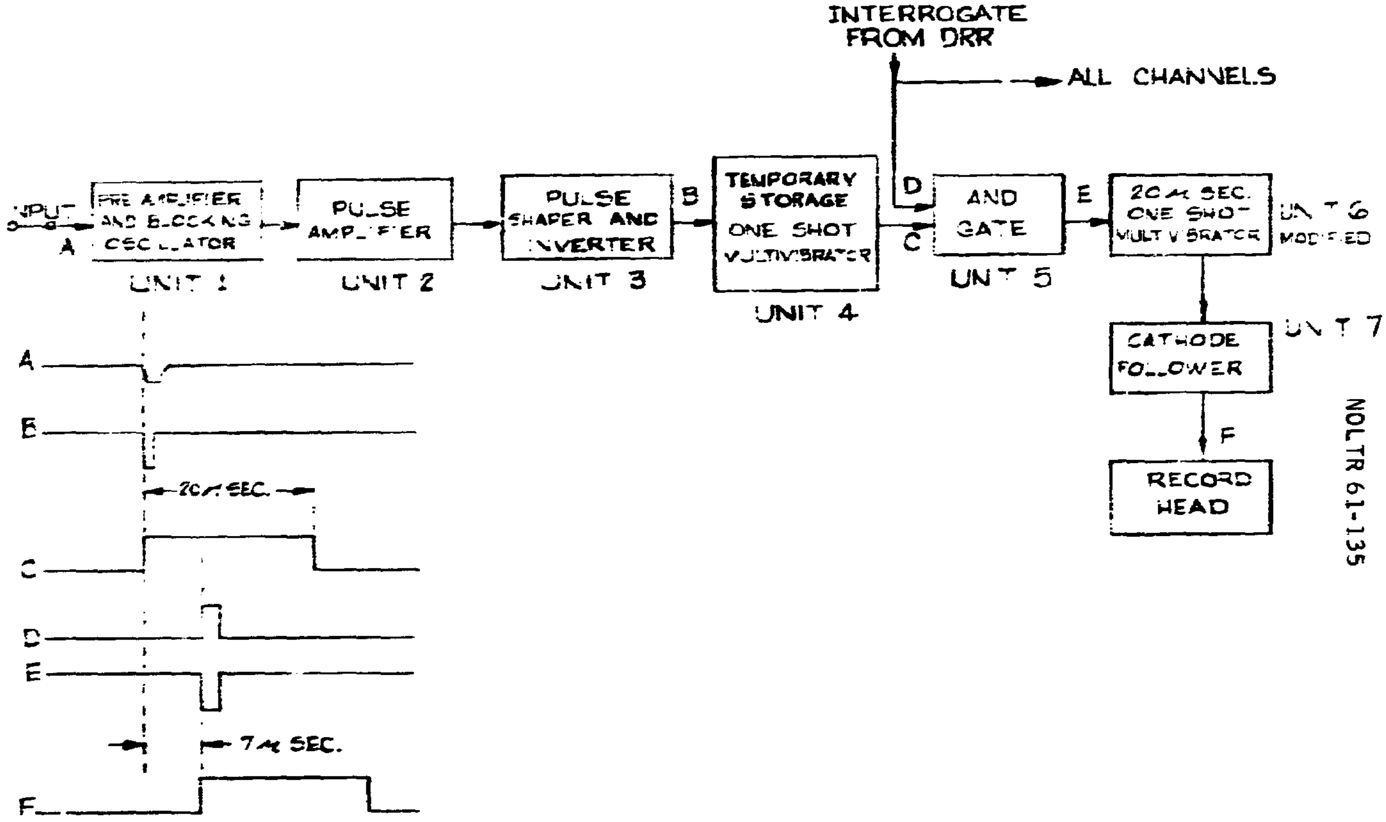


FIG. 3 TYPICAL RECORD CHANNEL BLOCK DIAGRAM WITH REPRESENTATIVE WAVEFORMS

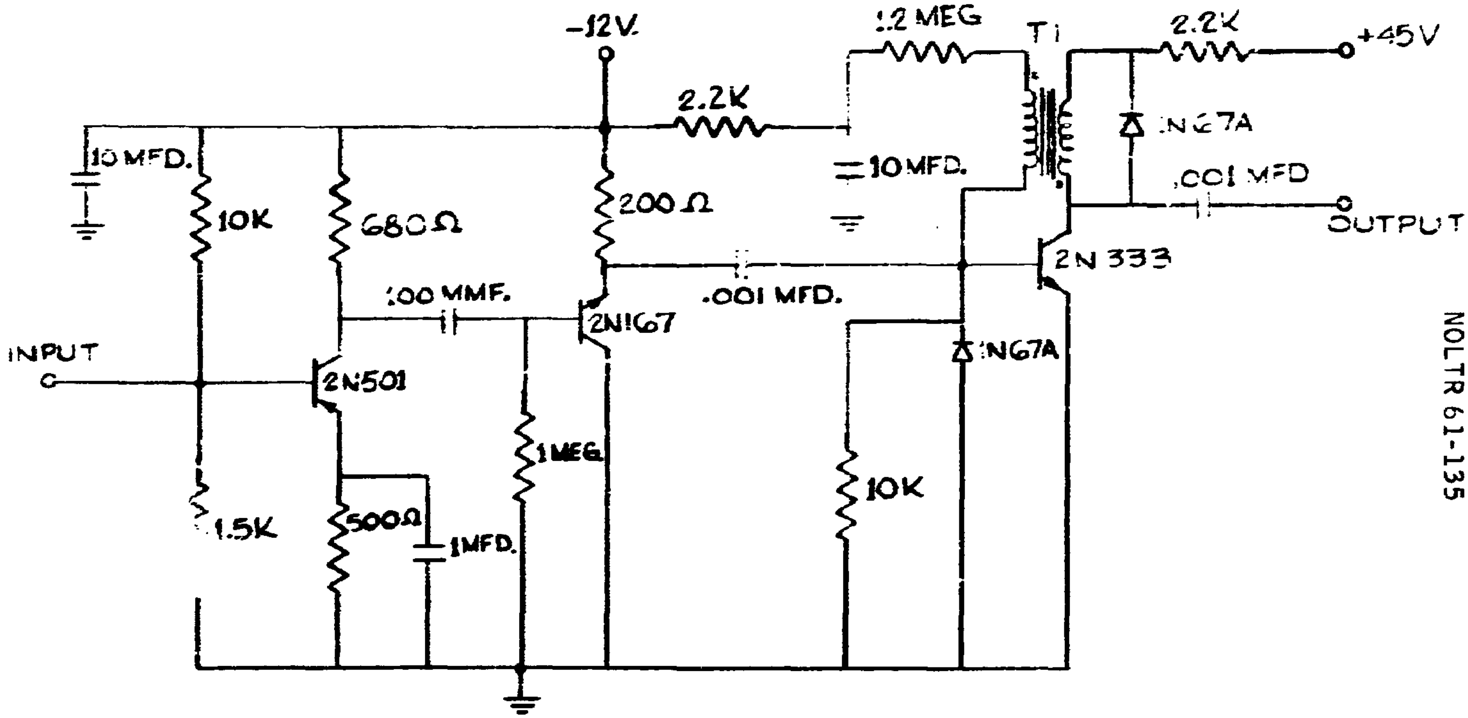
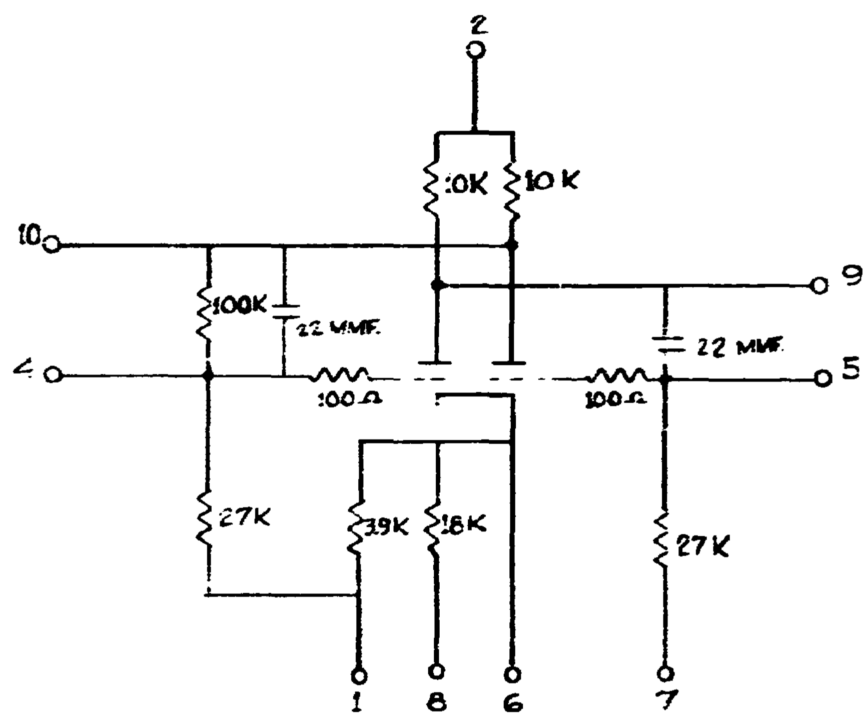


FIG. 4 SCHEMATIC DIAGRAM OF RECORD, PREAMPLIFIER AND BLOCKING OSCILLATOR



TUBE TYPE:5964

FIG.5 ONE SHOT MULTIVIBRATOR SCHEMATIC

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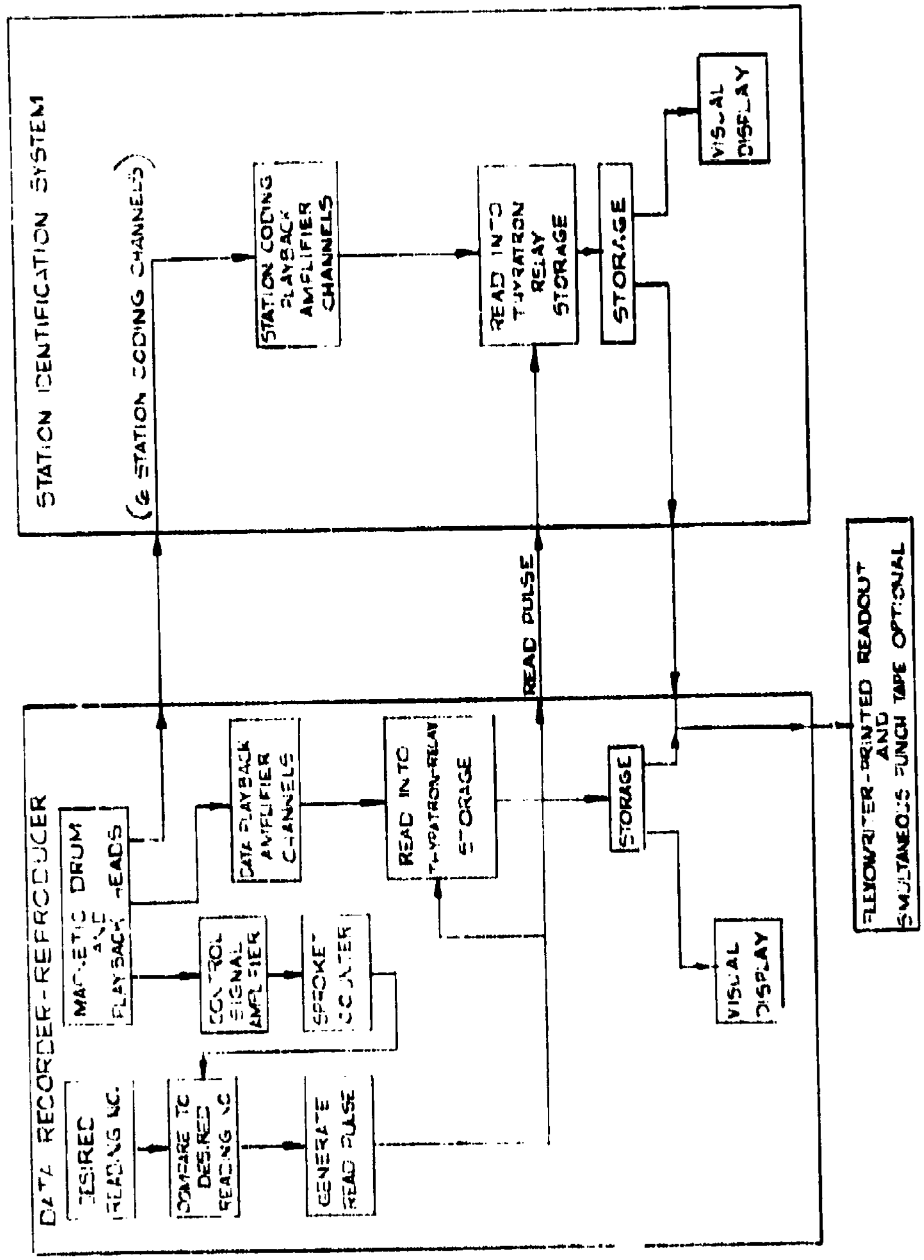

FIG.6 SIMPLIFIED PLAYBACK FLOW DIAGRAM

RANGE PBR **SHOT NO.** 4194 **DATE** 1-6-61 **TIME** 1035

READING MULTIPLIER (MICROSECONDS) 0.1

000	+022120	02
001	+030231	03
002	+035173	04
003	+043528	05
004	+048703	06
005	+056892	07
006	+061992	08
007	+070315	09
008	+075440	10
009	+083812	11
010	+088986	12
011	+097235	13
012	+102477	14
013	+110976	15
014	+116066	16
015	+124417	17
016	+138021	19
017	+143412	20
018	+169307	21
019	+195466	22
020	+221791	23
021	+248236	24
022	+274962	25

Station Number

Elapsed Time Data

Reading Number

FIG.7 TYPICAL SHOT DATA SHEET

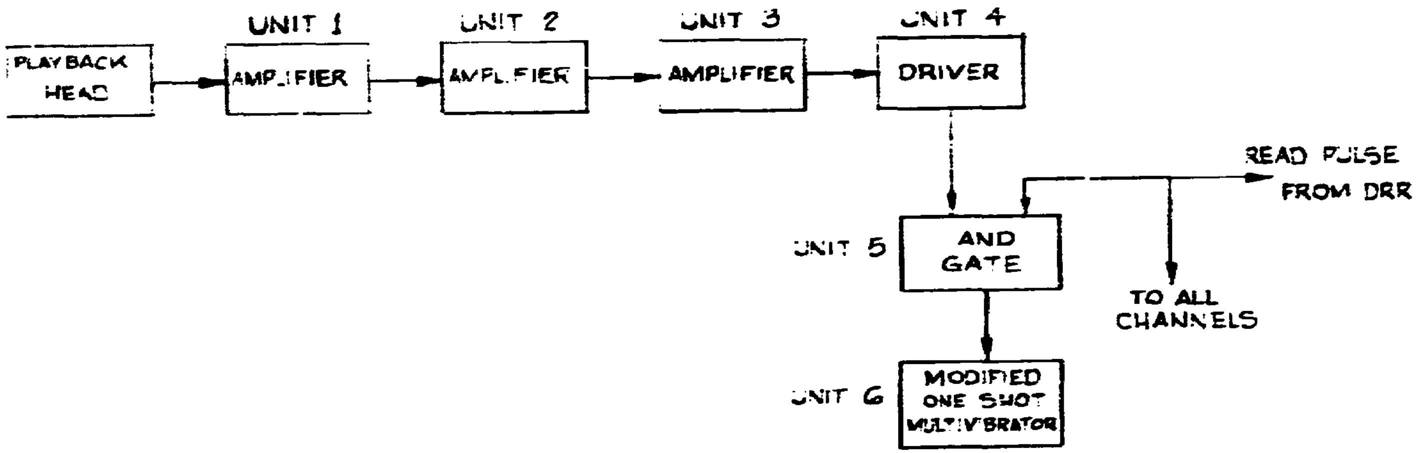

FIG.8 TYPICAL PLAYBACK CHANNEL BLOCK DIAGRAM

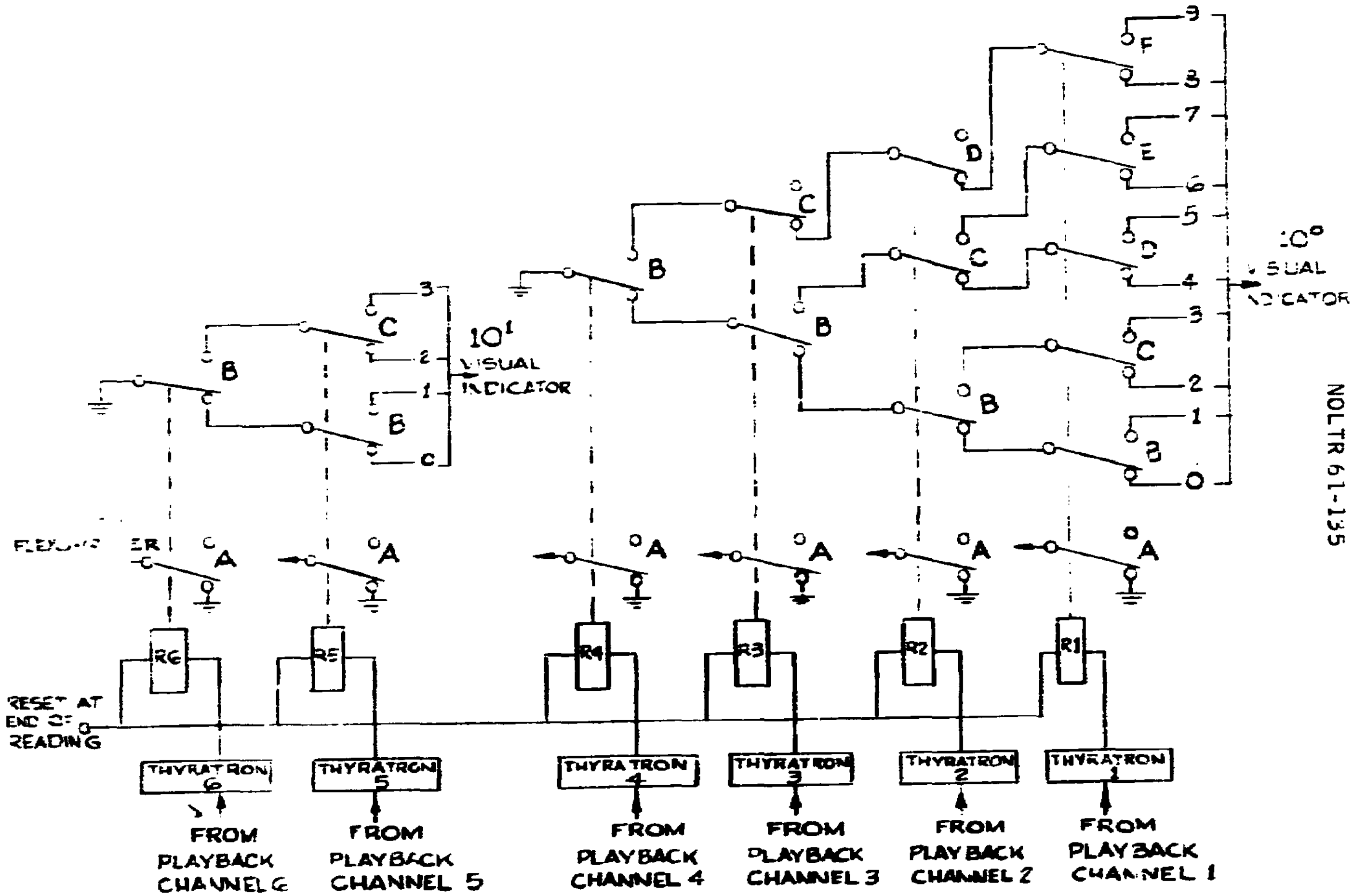

FIG. 9 THYRATRON-RELAY STORAGE AND CODE CONVERTER

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3. Flexowriter
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III. Series

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